SYSTEMS AND METHODS FOR HIGH DENSITY MULTI-COMPONENT MODULES

CROSS-REFERENCE RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Application Ser. No. 60/796,488, filed May 1, 2006, the entire contents of which are incorporated herein by reference.

FIELD OF INVENTION

[0002] The invention relates generally to systems and methods for fabricating high density multi-component modules.

BACKGROUND OF THE INVENTION

[0003] There is an increasing drive to integrate more devices with disparate capabilities into a single vanishingly-small package. This trend is driven by both consumer electronics and government applications, in which robust, long-life systems must perform continuous monitoring in hostile environments in order to supplement scarce human intelligence resources.

[0004] For example, electronic systems such as portable wireless communication devices or portable clinical diagnostic kits may require the integration of multiple capabilities, such as robust computational power, accurate imaging, guidance and navigation, biochemical detection, and robust and secure communications into a single package.

[0005] Traditionally, system and packaging design largely decouples the system components and addresses their development in parallel. This results in larger than optimal and power-inefficient systems. These are typically packaged individually into separate modules, wherein a module generally refers to a single substrate, interposer, or other support structure, with one or more components disposed thereon, with functional interconnections that couple the components to other devices.

[0006] In certain instances, multiple components may be packaged into a single module, but these components are typically all of the same technology type (i.e. all are digital integrated circuits, all are memory chips, etc.), all of the same material (i.e. a silicon communication layer stacked with a silicon imaging layer), or consist of a limited number of active devices (<5) packaged with a small number of passives (<10).

[0007] In order to approach the theoretical maximum component density and power efficiency for arbitrary materials, large numbers of components, and arbitrary interconnection paths (e.g. horizontal and vertical), the specification and design of the constituent subsystems must be conducted in a highly optimized and coupled manner. Additionally, the integration method must overcome the host of thermophysical incompatibilities encountered when interconnecting the platforms into a single device.

SUMMARY OF THE INVENTION

[0008] The invention addresses the deficiencies in the prior art by providing devices a subsystem packaging and interconnection method that incorporates a multitude of subsystem components and materials into a single platform. In one aspect, the invention provides a method of forming a device by which very high aspect ratio interconnecting structures are initially formed in a matrix through one of several possibilities.

[0009] In another aspect, the invention provides a device that incorporates several subsystem components on a single platform. The components can perform a wide variety of functions, and in certain embodiments include analog or digital integrated circuit components, wireless communication components such as radio frequency receivers and transmitters, optical signal processors, optical routing elements including waveguides, biological and chemical sensors, transducers, actuators, energy sources, MEMS devices, passive components, and other components that will be discussed in more detail below. In certain embodiments, a manufacturer incorporates nanoparticles into the materials that make up the device. The nanoparticles can be incorporated throughout the material to globally alter the materials' properties, but in other embodiments, the nanoparticles are introduced in certain regions near a subsystem component to improve the performance of that component, or in certain regions to serve as a subsystem component formed directly within the materials of the device.

[0010] In another aspect, the invention relates to a method of forming a device by which a first set of components arranged above a first substrate, a first encapsulating layer encapsulating the first set of components on the first substrate, is combined with a second set of components arranged over a second substrate, a second encapsulating layer encapsulating the second set of components on the second substrate, wherein at least one functional interconnect for interconnecting at least one of the second set of components with at least one of the first set of components.

[0011] In another aspect, the invention includes a device, comprising a substrate, a first set of components arranged above the substrate, a first encapsulating layer over the first set of components, a second set of components arranged above the first set of components, wherein the second set of components are predefined, a second encapsulating layer disposed over and encapsulating the second set of components and at least partially contacting the first encapsulating layer, and at least one functional interconnect for interconnecting at least one of the second set of components with at least one of the first set of components.

BRIEF DESCRIPTION OF THE FIGURES

[0012] The foregoing discussion will be understood more readily from the following detailed description of the invention with reference to the following drawings. The drawings may not be drawn to scale.

[0013] FIG. **1** is a cross sectional view of a multi-component module according to an illustrative embodiment of the invention.

[0014] FIG. **2** is a cross sectional view of components used to form the multi-component module of FIG. **1** at a first stage of manufacture, according to an illustrative embodiment of the invention.

[0015] FIG. **3** is a cross sectional view of components used to form the multi-component module of FIG. **1** after a first stage of manufacture, according to an illustrative embodiment of the invention.

[0016] FIG. **4**A is a cross sectional view of components used to form the multi-component module of FIG. **1** after a second stage of manufacture, according to an illustrative embodiment of the invention.